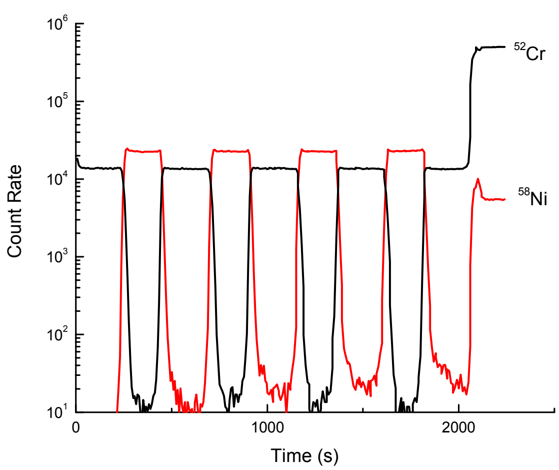
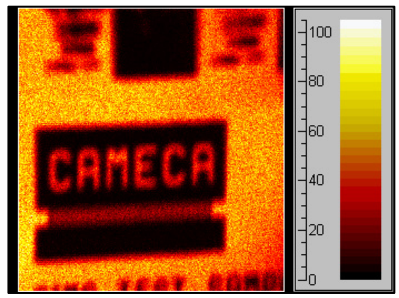
# $C_{60}^{+}$ Cluster Source for Secondary Ion Mass Spectrometry

*Novel primary ion beams for use in Secondary Ion Mass Spectrometry (SIMS) has shown great promise in analysis of a range of materials from polymer films to semiconductors. Experimentation with cluster ion beams has the potential to expand the application of SIMS to provide answers to important questions concerning materials composition and structure. The relatively large-area dispersion of energy by cluster ions into a surface during sputtering reduces beam-induced damage and can also increase the relative yield of higher molecular mass species sputtered from the surface. Previous experiments performed here at NIST with other cluster ion beams such as $SF_5^+$ have produced impressive results for sputtering and depth profiling of inorganic and organic materials. Recently $C_{60}^+$ has been investigated for use in time-of-flight (TOF) SIMS by other investigators with promising results.*

**A.J. Fahey and G. Gillen (Div. 837)**

NIST researchers obtained a $C_{60}^+$ source of the type used by other investigators on ToF-SIMS instruments and fitted it onto our dynamic SIMS instrument. Initial experiments show that the source can produce 25 nA to 50 nA of $C_{60}^+$ and ≈25 nA of $C_{60}^{2+}$. The ions are produced by electron impact on $C_{60}$ vapor. The beam current produced is quite stable and can be focused into a usable spot at the sample surface. An initially unexpected result is that $C_{60}^+$ does not produce any sputtering but instead, produces deposits at impact energies below ≈12 keV impact energy. Depth profiling with the $C_{60}^+$ ion beam was evaluated using a Ni/Cr multilayer test sample. This material typically roughens under ion bombardment making it difficult to discern the sharp boundaries between the layers. The graph shows a depth profile of the Cr-Ni multi-layer obtained with 14.5 keV $C_{60}^+$. The layers are clearly defined in this profile, with near constant secondary ion intensity in each of the respective layers. This profile is comparable to those obtained by other investigators who used a ToF-SIMS instrument but is obtained in considerably less time due to the higher current density obtained in the NIST dynamic SIMS instrument. In addition to depth profiling, the $C_{60}^+$ source is capable of imaging on the scale of a few micrometers.




An example image taken on a test-pattern sample is shown in figure below. This shows a micro-beam image taken with $C_{60}^+$. The image is approximately 500µm x 500 µm across.

The use of this source will allow us to explore semiconductor depth profiling of ever-shallower implants. As the lateral size of devices become smaller, the implant depth also becomes shallower. Thus to characterize cutting-edge electronics one must have high depth resolution.

Pharmaceutical companies are becoming increasingly interested in novel drug delivery systems that, for development and quality control purposes, must be characterized by techniques such as SIMS. The use of cluster ion sources has shown promise with these systems and the exploration of the application of $C_{60}$ to polymer depth profiling may improve the quality of these data even further.

***Future Plans:*** NIST researchers plan to explore novel applications of the $C_{60}$ ion source. One potential application may involve the measurement of nitrogen concentrations in ZrO films that are also used in the semiconductor industry. We plan to investigate the source parameters to obtain optimum performance of the source and the utilization of $C_{60}^{2+}$ for sputtering and analysis.